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Predicting and quantifying seated comfort while using two different seat cushioning materials

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ABSTRACT

Background: Adequate chair design and comfort are essential to the educational environment. *Aim:* The current study investigated the effect of cushion characteristics on student comfort during class time, aiming to increase the students' comfort and positively affect their academic gain. *Material and methods:* Thirty-nine volunteer female students participated in this study. Two types of foam were used; the first type was characterized by a density of 25kg/m3, hard, and elasticity of 80.15 N/cm2. The second type was characterized by a 26kg/m3 density, softness, and elasticity of 26.081 N/cm2.The dimensions used for the cushions of both types of foam were 40cm*40cm for both the seat pan cushion and back support cushion, a thickness of 8 cm for the seat pane cushion, and 4cm for the back support. The body part discomfort scale and Comfort and discomfort scale were used for assessment after using the cushions for one and a half hours. *Results:* The results revealed that general comfort and body part comfort were not different when comparing both cushions. On the other hand, the intensity of pain in the body part discomfort significantly increased when using hard cushioning. *Conclusion:* Cushion hardness did not affect the subjective sensation of comfort and discomfort, while a hard cushion may cause pain in certain body parts during use.

Keywords: Seat, comfort, cushion

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1. INTRODUCTION

The class environment has an imperative effect on academic achievement. The physical classroom environment includes various things, such as temperature, lighting, ventilation, room dimensions, floor, desks, chairs, and whiteboards. Instructors and students are the focal elements of the classroom environment. So, adequate chair design and chair comfort are essential components of the educational environment (Suleman and Hussain, 2014; Mohammad and El-Sais, 2013). Chair users need help distinguishing between seats based on various ergonomic qualities. They are imprecise because people cannot notice many ergonomic features that reduce pain while sitting. Lack of proprioceptive signals from muscles, joints, tendons, and the spine might cause this. The joints are primarily unable to detect little changes in the joint's range of motion, and the spine cannot identify pressure differences resulting from different body postures. Aesthetics criteria, instead, and criteria related to comfort and relaxation, are the easiest to be perceived by the user and distinguished (Helander, 2003).

The prolonged interaction between the chair and the user's body causes an increased load on the buttocks, thighs, and back. Poor design of chairs can evoke discomfort for the user. Prolonged time of discomfort influences work efficacy and can lead to musculoskeletal disorders (Fujimaki and Mitsuya, 2002). Chair design and material properties have a significant effect on comfort. Office chair comfort is mainly influenced by the seat pan's cushioning (Min et al., 2014). A seat pan could be a source of compression on the back joints. Mastalerz and Palczewska, (2010) investigated the effect of seat pan criteria on the muscular activities of the trunk and concluded that seat pan criteria affect muscular activities when measured by EMG. The studied criteria were seat pan hardness, tilt, and cushioning. Seat pan cushioning is available in different levels of hardness and densities. Candy et al., (2012) concluded that high-density foam seating wedges reduce the pain intensity of the back, especially at night, in school students aged 14-16.

Comfort is one of the most critical aspects of seat design. Static Comfort is assumed to be influenced by the static seat's size, shape, and hardness. To comprehend seat comfort, it is vital to connect the physical properties of seats to the sitting experience. This will also be helpful when constructing seats since it will be possible to forecast comfort based on the physical characteristics of the seats and modify some aspects of the seats to modify the sitting feeling (Ebe and Griffin, 2001). Seating comfort/discomfort is based on a subjective sensation. There are three possible approaches to indicating sitting comfort and discomfort levels: Anthropometry, subjective assessment, and objective measurements. The subjective assessment is the only method to evaluate comfort and discomfort, using self-reported surveys such as the "general comfort rating", "body area comfort rating", "method of adjustment", "Chair Feature Checklist", or "personal comments" (Vergara and Page, 2002). Seat pan and backrest cushioning characteristics can be important in the chair-user interaction.

For example, about a fifty percent decrease in the average seat pressure of a wheelchair because of various cushioning (Reenalda et al., 2009). De-Looze et al., (2003) determined that the pressure distribution at the pan of the car's chair related to subjective ratings of comfort/discomfort. Also, Groenesteijn et al., (2009) and Vergara and Page, (2000) conducted studies concerning office chairs, and they found a relationship between pressure distribution and comfort/discomfort assessment. Helander, (2003) states that comfort and discomfort are distinct identities accompanying various predisposing issues. Discomfort is related to pain sense, muscular soreness, and tingling and is a result of physical constrictions in the used model. Comfort, instead, is related to well-being sense and relaxation and may be affected by aesthetic aspects of the product. Therefore, a reduction in the experienced discomfort level may not indicate an increase in the comfort level; on the other hand, Low discomfort is necessary to reach a high degree of Comfort (Hiemstra-van-Mastrigt et al., 2017). Accordingly, the current study aimed to investigate the effect of two types of seat cushioning on body comfort during sitting in class to increase the students' comfort and positively affect their academic gain.

2. SUBJECTS, MATERIALS AND METHODS

Study setting

The current study was performed at the College of Applied Medical Sciences' female section. Its aim was to investigate the effect of two types of seat cushioning on body comfort during class sitting.

Subjects

Thirty-nine female students participated in this study. They were volunteers. To be eligible, participants were required to be female, Saudi citizens between the ages of 20 and 22, without any chronic disease, and between 155 and 165 cm in height and 52 and 60 kg in weight.

Materials and Methods

Instruments

The chair

We used the most available chair in the college with the following parameters: Seat pan height 42 cm, Seat pan Depth 45.5 cm, Seat pan Width 45 cm, Backrest height 40 cm, Backrest width 44.5 cm, Movable task surface height from lateral side 73 cm, Movable task surface height from anterior surface 73.5 cm (Figure 1).

Cushion

We used two types of foam. The first type is characterized by a 25kg/m3 density, hardness, and elasticity of 80.15 N/cm2. The second type is characterized by a 26kg/m3 density, softness, and elasticity of 26.081 N/cm2. The dimensions used for the cushions of both types of foam were 40cm*40cm for both the seat pan cushion and back support cushion, a thickness of 8 cm for the seat pane cushion, and 4cm for the back support. The used thickness was selected as it maximally decreases the pressure on the body's tissues during sitting (Reenalda et al., 2009).

Comfort and discomfort scale

The scale was used to evaluate the subjective comfort/discomfort. It plays a significant function in the interface analysis of pressure distribution and subjective evaluations of comfort/discomfort (Shen and Parsons, 1997). The Helander comfort and discomfort scale items were selected to illustrate the dimensions of comfort and discomfort. Comfort indicates well-being, impression, and plushness; discomfort indicates fatigue, poor biomechanics, and restlessness. There are nine items related to discomfort and seven related to comfort. This scale was validated by (Helander and Zhang, 1997).

Body part discomfort scale: (Appendix I)

We used a body part chart that illustrates different body regions in association with the Borg Rate of Perceived Pain Scale Borg, (1998), according to (Haynes and Williams, 2008). Borg rate of perceived pain will be used as a valid and reliable method for assessing pain and subjective somatic symptoms.

Procedures

We illustrated all procedures and the assessment tools to the students who fulfilled the required criteria after taking their height and weight. If the student agreed to participate, we asked her to complete the consent form. The students were allowed to use the two cushion types for one and a half hours for each type during class time. She chose the class she preferred to use the cushion. She was instructed about the proper sitting posture to use during cushion use. She should use the role of 90, maintaining 90-degree hip flexion, 90-degree knee flexion, and the foot resting on the ground or supporting step.

The order of introducing the two types was randomized. By the end of the one-and-a-half hour of cushion usage, the Comfort and discomfort scale and Body part discomfort scale were introduced to the volunteer. The subject selected only one item from the comfort and discomfort scale. If the subject had painful regions after sitting, she selected them on the body region chart, and then she rated the pain intensity on the Borg Rate of Perceived Pain Scale. The items to be assessed will be the rank of the Body part discomfort scale, the number of affected regions, and the mean score of the affected regions.

3. RESULTS

The current study aimed to investigate the appropriate cushion characteristics from commercially available cushions. The tested parameters were general comfort and discomfort "using the Comfort and Discomfort scale" and body part discomfort "using the Body

Part Discomfort scale", which measures the frequency and intensity of body part affection. The Shapiro-Wilk test, skewness, and kurtosis and their standard error showed that the data were not normally distributed. So, as an alternative to repeated measure ANOVA, we used the Friedman and Wilcoxon Signed Ranks tests as post hoc tests. The mean rank of the Comfort discomfort scale was 5.25 and 5.46 for the hard and soft cushions, respectively.

According to the Body part discomfort scale, the mean rank for intensity was 3.19 and 2.07 for the hard and soft cushions, respectively. For the body part discomfort frequency, the mean rank for the hard cushion was 2.78, and for the soft cushion was 2.25 (Table 1). Only the body part comfort scale intensity showed a significant increase when using the hard cushion compared to the soft cushion. The other variables did not show any significant difference (Table 2). Spearman's Rank-Order Correlation was conducted to detect the correlation between the comfort discomfort scale results and the intensity of the Body part discomfort scale. The results indicated that as the Comfort Discomfort scale score increased (which indicates an increase in the level of comfort), the intensity of pain affected the body part decreased (Table 3).

Table 1 Ranks of the study variables.

	Mean Rank
Comfort hard	5.25
Comfort soft	5.46
body part int. hard	3.19
Body part int. soft	2.07
Body part freq. soft	2.25
body part freq. hard	2.78

Comfort: Comfort Discomfort scale
Body part int.: Intensity of body part scale
Body part freq.: Frequency of body part scale
Soft: Soft cushion.
Hard: Hard cushion

Table 2 Friedman and Wilcoxon tests.

Friedman test		
Chi-Square	114.05	
Asymp. Sig.	0.00*	
Post hoc test (Wilcoxon)		
Pairs	Z	Asymp. Sig. (2-tailed)
Comfort soft Comfort hard	-1.704	.088
Body part int. soft body part int. hard	-2.359	.018*
Body part freq. soft body part freq. hard	-.438	.661

*: Significant findings at 0.05 level

Table 3 Spearman's Rank Order Correlation

Pairs	Correlation Coefficient	Sig. (2-tailed)
Comfort hard Body part int. hard	-0.48**	0.003
Comfort soft. Body part int. soft	-.565**	0.001

**: significant findings at 0.01 level

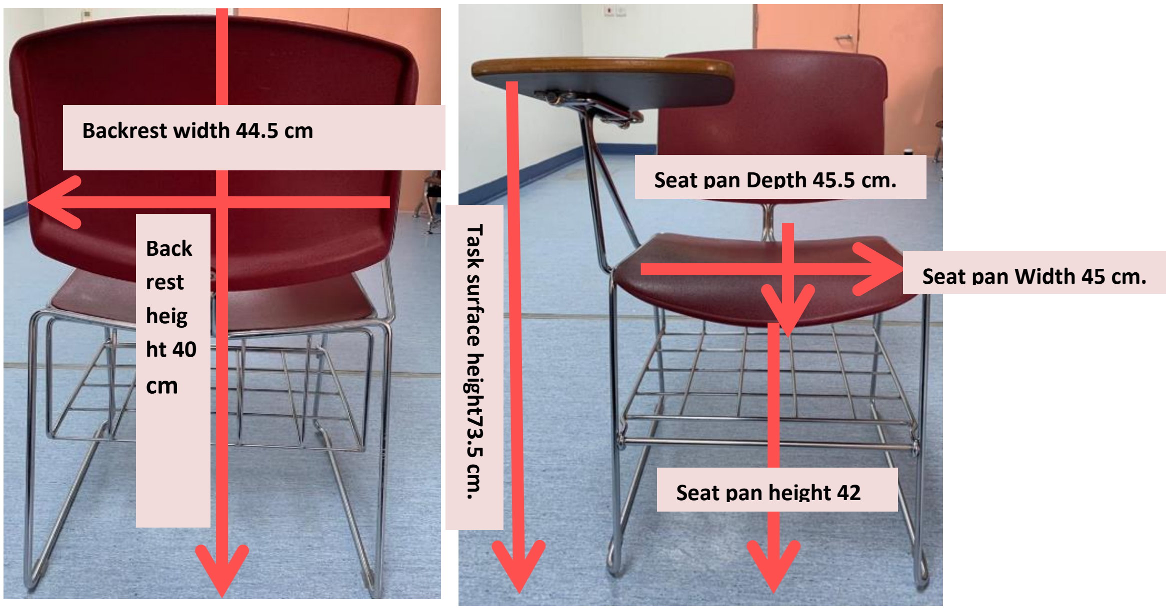

Figure 1 Dimensions of the chair

4. DISCUSSION

Our study showed a non-significant difference between the Comfort Discomfort scale results when using the two cushioning types, "soft and hard". This may be due to the difference in the user's personal preferences. Personality traits may play an essential role in determining personal preferences for chairs and office furniture, as stated by Ko et al., (2018), who investigated how various personality factors affected the evaluation of office chairs. Ojennus and Watts, (2017) also recommend different comfortable soft seating options for all students during library time. Many other factors affect comfort rather than the seat's softness, such as the skin's pressure sensitivity Vink and Lips, (2017) and underlying tissue and contact surface area (Antal et al., 2017). Additionally, Tan et al., (2011) mentioned that psychological factors (such as body shape and posture) can influence the subject comfort.

Prior experience with seat features is another important factor when rating a new chair, and this experience may differ from one person to another (Van-Veen and Vink, 2016). On the other hand, Hiemstra-van-Mastrigt et al., (2015) reported that up till now, numerous earlier research works have examined the association between pressure and the subjective perception of comfort and discomfort; however, because of differences in research design, the findings of these studies are not congruent with one another. As a result, this correlation's strength is weak. There was much research regarding comfort levels when using hard or soft cushions. Mohanty and Mahapatra, (2014) preferred using soft cushioning during their study of the effect of cushion thickness and type on comfort.

Additionally, Moon et al., (2020) mentioned that an increase in the comfort of the seat is associated with soft cushion as it increases the contact area and decreases the pressure on the soft tissues. Additionally, the results of this study revealed that the pain intensity increased during using the hard cushion. Such finding may be attributed to decreased tissue oxygenation, which causes affection to this tissue and increases the sense of pain (Reenalda et al., 2009). Moreover, the increased pressure may cause tissue ischemia, which leads to pain (Oomens et al., 2015). Despite this effect of using hard cushioning due to the pressure, it still comforts certain categories in the population. Radwan et al., (2015) examined the impact of mattress hardness on sleep comfort, and they reported that mattresses with medium hardness are more comfortable for individuals with back pain than soft mattresses.

5. CONCLUSION

The subjective sensation of comfort and discomfort during chair use is affected by various factors rather than the cushioning hardness. Subjects differ in their preferences regarding the hardness of the cushion. On the other hand, we should consider the effect of using a hard cushion, which can cause pain after long-term usage.

Limitations of the study

During our study, the students' sitting posture wasn't monitored during class. Although the students were instructed about good sitting posture, it would be difficult to frequently interrupt the class to modify any deviation from the proper sitting posture. Also, the psychological status of the students may differ from one to another while using different seat cushioning.

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Authors' Contributions

Study design: Lamiaa K Elsayyad, Alsufiany Muhsen, Fahad Hadi Alshehri
Literature search: Lamiaa K Elsayyad, Hatem H Allam, Alsufiany Muhsen, Fahad Hadi Alshehri
Data collection: Ashwag M Althobaiti, Ohood A Al-sufyani, Smah S Alkhalidi, Sundous F Bokhari, Mashael H Alwagdani, Arwa S Althuwaybi, Amani H AlGhamdi, Alanoud T Alotaibi, Sumayah M Alshomrani, and Rimaz S aljohani.
Statistical analysis: Hatem H Allam and Lamiaa K Elsayyad
Data interpretation: Hatem H Allam and Lamiaa K Elsayyad
Manuscript preparation: Lamiaa K Elsayyad and Hatem H Allam

Ethical Approval

The Research and Studies Department, Directorate of Health Affairs, Ministry of Health, Taif, KSA, approved the study (approval No, 322).

Informed Consent

Written informed consent was collected from all participants.

Funding

This study has not received any external funding.

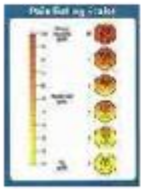
Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

Appendix I: Body part discomfort scale



Handout:

UT Extension

Borg Rate of Perceived Pain Scale

The Rating of Perceived Pain (RPP) Measuring Scale*

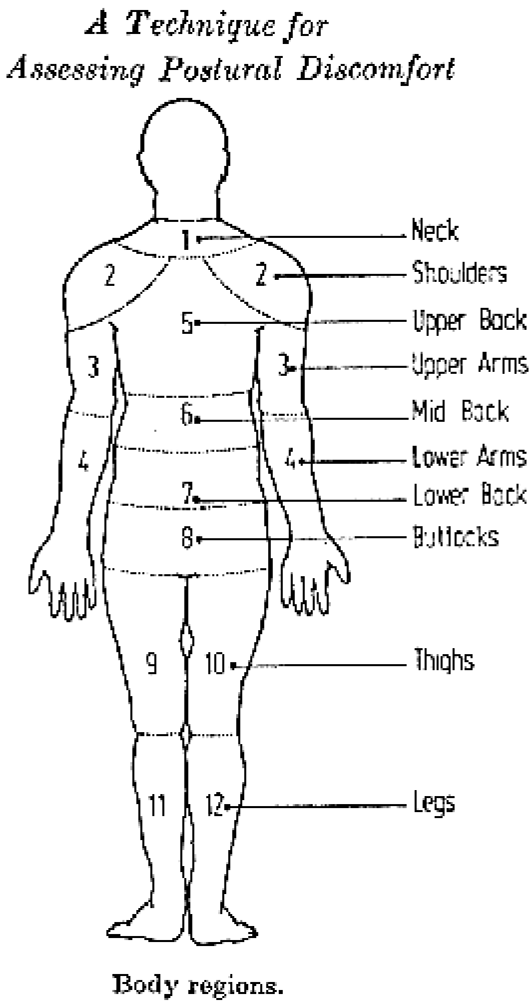
Use this quantitative scale to evaluate any pain you feel during your IBC workout, following the instructions below.

Rating	Subjective Feeling
0	**Nothing at all (no soreness/other pain)**
0.3	
0.5	**Extremely weak (just noticeable soreness/other pain)**
0.7	
1	**Very weak**
1.5	
2	**Weak (light intensity soreness/other pain)**
2.5	
3	**Moderate**
4	
5	**Strong (heavy intensity soreness/other pain)**
6	
7	**Very strong**
8	
9	
10	**Extremely strong (strongest intensity soreness/other pain)**
11	
●	**Absolute maximum (highest possible intensity soreness/other pain)**

Instructions for use: During the exercise…pay close attention to any pain you may feel anywhere in your body, including muscle soreness, joint, or trunk pain. Concentrate on the pain and estimate its intensity using the above scale. Try not to underestimate or overestimate your feeling of pain; be as accurate as you can.

* From; Gunnar Borg, G. *Borg's Perceived Exertion and Pain Scales* (Champaign, IL: Human Kinetics, 1998). Reproduced with the permission of the author.

Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating. UT Extension provides equal opportunities in programs and employment.



(Adopted from Vergara and Page, 2002)

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